

## CLAIMS

1           1.     A pixel comprising:

2           a)     a substrate having a photodiode, said photodiode having a light  
3     receiving area;

4           b)     a color filter array (CFA) material of a first color disposed above said  
5     substrate, said pixel having a first relative responsivity; and

6           c)     a light shield disposed above the substrate, said light shield forming  
7     an aperture, said aperture having an area substantially equal to the light  
8     receiving area adjusted by a reduction factor, said reduction factor being a result  
9     of an arithmetic operation between the first relative responsivity and a second  
10    relative responsivity associated with a second pixel of a second color.

1           2.     The pixel of claim 1 wherein the reduction factor is the result of the  
2     first relative responsivity divided by the second relative responsivity.

1           3.     The pixel of claim 1 wherein the light shield includes a metal layer.

1           4.     The pixel of claim 1 wherein the light shield includes an opaque  
2     material.

1           5.     The pixel of claim 4 wherein the opaque material is a dielectric  
2 material.

1           6.     The pixel of claim 5 wherein the dielectric material includes a  
2 silicon dioxide.

1           7.     The pixel of claim 1 wherein the pixel is a green pixel and the  
2 second pixel is a blue pixel.

1           8.     The pixel of claim 1 wherein the pixel is a red pixel and the second  
2 pixel is a blue pixel.

1           9.     A method comprising the steps of:  
2           a)     determining a relative responsivity ( $S_1$ ) for a pixel of a first color;  
3           b)     determining a relative responsivity ( $S_2$ ) for a pixel of a second color;  
4           c)     determining whether the relative responsivity ( $S_1$ ) for the first pixel  
5 is more than the relative responsivity ( $S_2$ ) of the second pixel;

6                 if yes, forming a mask opening above the first pixel, said mask  
7 opening having an area substantially equal to the light receiving area  
8 adjusted by a reduction factor, said reduction factor being a result of an  
9 arithmetic operation between the relative responsivity of the first pixel

10 and the relative responsivity of the second pixel; and forming a mask  
11 opening above the second pixel, said mask opening having an area  
12 substantially equal to the light receiving area;

13 else,

14 forming a mask opening above the first pixel, said mask  
15 opening having an area substantially equal to the light receiving  
16 area; and

17 forming a mask opening above the second pixel, said mask  
18 opening having an area substantially equal to the light receiving  
19 area adjusted by a reduction factor, said reduction factor being a  
20 result of an arithmetic operation between the relative responsivity  
21 for a second pixel and the relative responsivity of the first pixel.

1 10. The method of claim 9 wherein the light receiving area is  
2 multiplied by the reduction factor.

1 11. The method of claim 9 wherein the arithmetic operation is a  
2 division operation.

1 12. A method to pattern an array comprising the steps of:

2 a) determining a relative responsivity ( $S_1$ ) for pixels of a first color;

3 b) determining a relative responsivity ( $S_2$ ) for pixels of a second color;

4 c) determining a relative responsivity ( $S_3$ ) for pixels of a third color;  
5 d) determining whether the relative responsivity ( $S_1$ ) for pixels of the  
6 first color is lower than the relative responsivity ( $S_2$ ) of pixels of the second color  
7 and the relative responsivity ( $S_3$ ) of pixels of a third color;

8 e) if yes,

9 forming a mask opening above the pixels of the first color,  
10 said mask opening having an area substantially equal to the  
11 predetermined light receiving area;

12 forming a mask opening above the pixels of the second color,  
13 said mask opening having an area substantially equal to the  
14 predetermined light receiving area adjusted by a reduction factor,  
15 said reduction factor being a result of an arithmetic operation  
16 between  $S_1$  and  $S_2$ ; and

17 forming a mask opening above the pixels of a third color, said  
18 mask opening having an area substantially equal to the  
19 predetermined light receiving area adjusted by a reduction factor,  
20 said reduction factor being a result of an arithmetic operation  
21 between  $S_1$  and  $S_3$ .

1 13. The method of claim 12 wherein the mask opening formed above  
2 the pixels of the second color has an area substantially equal to the  
3 predetermined light receiving area multiplied by ( $S_1/S_2$ ); and the mask opening  
4 formed above the pixels of a third color has an area substantially equal to the  
5 predetermined light receiving area multiplied by ( $S_1/S_3$ ).

1           14.    The method of claim 12 further comprising the steps of:

2           a)    determining whether the relative responsivity ( $S_2$ ) for pixels of the  
3 second color is less than the relative responsivity ( $S_1$ ) of pixels of a first color and  
4 the relative responsivity ( $S_3$ ) of pixels of a third color;

5           b)    if yes,

6                   forming a mask opening above the pixels of the second color,  
7 said mask opening having an area substantially equal to the  
8 predetermined light receiving area;

9                   forming a mask opening above the pixels of the first color,  
10 said mask opening having an area substantially equal to the  
11 predetermined light receiving area adjusted by a reduction factor,  
12 said reduction factor being a result of an arithmetic operation  
13 between  $S_2$  and  $S_1$ ; and

14                   forming a mask opening above the pixels of a third color, said  
15 mask opening having an area substantially equal to the  
16 predetermined light receiving area adjusted by a reduction factor,  
17 said reduction factor being a result of an arithmetic operation  
18 between  $S_2$  and  $S_3$ .

1           15.    The method of claim 12 wherein the mask opening formed above  
2 the pixels of the second color has an area substantially equal to the  
3 predetermined light receiving area multiplied by ( $S_2/S_1$ ); and the mask opening  
4 formed above the pixels of a third color has an area substantially equal to the  
5 predetermined light receiving area multiplied by ( $S_2/S_3$ ).

1           16.    The method of claim 12 further comprising the steps of:

2           a)    determining whether the relative responsivity ( $S_3$ ) for pixels of a  
3 third color less than the relative responsivity ( $S_1$ ) for pixels of a first color and  
4 the relative responsivity ( $S_2$ ) for pixels of a second color;

5           b)    if yes,

6                   forming a mask opening above the pixels of a third color, said  
7 mask opening having an area substantially equal to the  
8 predetermined light receiving area;

9                   forming a mask opening above the pixels of a first color, said  
10 mask opening having an area substantially equal to the  
11 predetermined light receiving area adjusted by a reduction factor,  
12 said reduction factor being a result of an arithmetic operation  
13 between  $S_3$  and  $S_1$ ; and

14                   forming a mask opening above the pixels of a second color,  
15 said mask opening having an area substantially equal to the  
16 predetermined light receiving area adjusted by a reduction factor,  
17 said reduction factor being a result of an arithmetic operation  
18 between  $S_3$  and  $S_2$ .

1           17.    The method of claim 12 wherein the mask opening formed above  
2 the pixels of the second color has an area substantially equal to the  
3 predetermined light receiving area multiplied by ( $S_3/S_1$ ); and the mask opening  
4 formed above the pixels of a third color has an area substantially equal to the  
5 predetermined light receiving area multiplied by ( $S_3/S_2$ ).

1           18.    The method of claim 12 wherein the step of determining the  
2   relative responsivity ( $S_1$ ) for pixels of a first color includes the steps of:

- 3           a)     determining an input photodiode responsivity;
- 4           b)     determining an input color filter array transmittance for the first  
5   color;
- 6           c)     determining an input IR blocking filter characteristic;
- 7           d)     computing a net response by multiplying the input photodiode  
8   responsivity, the input color filter array transmittance for the first color, and the  
9   input IR blocking filter characteristics;
- 10          e)     determining an input light source spectral characteristic; and
- 11          f)     convolving the net response and the light source spectral  
12   characteristics to generate the relative responsivity ( $S_1$ ) for the first color.

1           19.    The method of claim 12 wherein the step of determining the  
2   relative responsivity ( $S_2$ ) for pixels of a second color includes the steps of:

- 3           a)     determining an input photodiode responsivity;
- 4           b)     determining an input color filter array transmittance for the second  
5   color;
- 6           c)     determining an input IR blocking filter characteristic;

7           d)     computing a net response by multiplying the input photodiode  
8     responsivity, the input color filter array transmittance for the second color, and  
9     the input IR blocking filter characteristics;

10          e)     determining an input light source spectral characteristic; and

11          f)     convolving the net response and the light source spectral  
12     characteristics to generate a relative responsivity ( $S_2$ ) for the second color.

1           20.    The method of claim 12 wherein the step of determining the  
2     relative responsivity ( $S_3$ ) for pixels of a third color includes the steps of:

3           a)     determining an input photodiode responsivity;

4           b)     determining an input color filter array transmittance for the third  
5     color;

6           c)     determining an input IR blocking filter characteristic;

7           d)     computing a net response by multiplying the input photodiode  
8     responsivity, the input color filter array transmittance for the third color, and the  
9     input IR blocking filter characteristics;

10          e)     determining an input light source spectral characteristic; and

11          f)     convolving the net response and the light source spectral  
12     characteristics to generate a relative responsivity ( $S_3$ ) for the third color.



1           21.    The method of claim 12 wherein the first color is red, the second  
2 color is green and the third color is blue.

1           22.    A method for manufacturing an improved pixel cell that employs a  
2 first metal layer as a light shield comprising the steps of:

3           a)     forming a substrate having active devices, said active devices  
4 including a photodiode;

5           b)     depositing a dielectric layer on the substrate;

6           c)     performing via lithography and etch on the dielectric layer;

7           d)     depositing a metal in the via;

8           e)     polishing the metal;

9           f)     depositing a metal layer on the dielectric layer; and

10          g)     performing lithography and etch on the metal layer by employing a  
11 metal mask, said metal mask having a plurality of openings; wherein the mask  
12 opening above pixels of a first color having a lowest responsivity is equal to the  
13 area of the predetermined light receiving area; wherein the mask opening above  
14 pixels of a second color having a responsivity greater than the responsivity of  
15 pixels of the first color is equal to the predetermined light receiving area  
16 multiplied by  $S_1$  divided by  $S_2$  where  $S_1$  is the relative responsivity of the first  
17 color and  $S_2$  is the relative responsivity of the second color; and

18          wherein the mask openings above the pixels of a third color having a  
19 responsivity greater than the responsivity of pixels of the second color is equal to

- 20 the predetermined light receiving area multiplied by  $S_1$  divided by  $S_3$  where  $S_3$  is  
21 the relative responsivity of the third color.

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